

Independent Review of the Scientific Management Recommendations
in the
June 1998 Large Coastal Shark Evaluation Workshop Report

Statement: I have reviewed the June 1998 Large Coastal Shark Evaluation Workshop (SEW) Report and the 50 other documents submitted by the Court for review and have come to the following conclusions regarding the scientific management recommendations contained in the 1998 SEW Report.

Court Directed Question:

Response in respect to the Court requirement that, *“Each reviewer must make one overall statement as to whether the scientific conclusions and scientific management recommendations contained in the 1998 SEW Report are based on scientifically reasonable uses of the appropriate fisheries stock assessment techniques and the best available (at the time of the 1998 SEW Report) biological and fishery information relating to large coastal sharks.”*

Response:

Following the Court directed question, my perspective is as follows:

I **do not** believe that the scientific management recommendations contained in the June 1998 SEW Report are based on scientifically reasonable uses of appropriate fisheries stock assessment and the best available science (at the time of the 1998 SEW Report).

Response in respect to the Court requirement that, *“In reaching this conclusion, reviewers are expected to determine (1) whether the model used to estimate large coastal shark population abundance and demographic trends is reliable and scientifically rigorous and (2) whether the scientific conclusions and scientific management recommendations are based on a logical extension of the model’s results.”*

Question 1. *Was the model used to estimate large coastal shark population abundance and demographic trends reliable and scientifically rigorous?*

Response:

The Bayesian approach is widely accepted as an appropriate modeling technique, which can be helpful when there is uncertainty regarding the various life history parameters of a species and

can provide a range of management options for managers to consider. However, acceptance of the results and model outputs (for any model) depends on the underlying assumptions in the stock assessment (production model), selected intrinsic rate (r) for population increases, and the assumed carry capacity (K) for the Large Coastal Sharks (LCS). A major weakness in the approach is that the model parameters are defined in terms of maximum intrinsic rate of increase and carrying capacity and not in terms of natural mortality and recruitment. Maximum intrinsic rate of increase is based largely on survivorship of age-classes, but as noted in the 1996 SEW Report (NRC-LCS-32) survivorship of age-classes is uncertain, so the modelers selected survivorship patterns based on the scant literature and on the most pessimistic scenarios.

The production model assumes a closed population, but the tagging data do not seem to support this conclusion. The model also does not allow for population changes due to environmental stochasticity, which may have been significant over the time period considered in the model. Also, knowledge of dispersal rates, spatial composition of shark populations and stock-recruitment dynamics is limited and not fully included in the modeling. Bayesian modeling also depends, to a large extent, on the assumed “Vital Rates” of the species, based on what is referred to as “priors” or documented historical information. However, as pointed out by Cortes (NRC-LCS-10), in sharks, knowledge of vital rates is fragmentary at best due to the lack of basic biological information. “Priors” are said to have been derived from the published literature, but there is no clear summary (tabular or otherwise) of information upon which one can evaluate the reliability of important life history features, such as age-at-maturity, longevity, juvenile survivorship, and natural mortality rates. Although these features are summarized briefly for several LCS species under the heading “Vital Rates” in each of the SEW Reports, for most of the LCS species no data is provided. There is no information or data on what samples sizes, location of samples or times were used to determine these important parameters, nor is there a synthesis of applicable shark tagging data.

If the industry claim is true, that the age at maturity for sandbar sharks was established based on a single return of a female sandbar shark marked with tetracycline, then the modelers are grasping at straws. The questionable quality of the catch data (especially during the early years, 1980-1990), speculated on life history features, and assumed “priors” might well force the Bayesian model to produce unreliable results, thus yielding population trends inconsistent with most of the CPUE data sets in recent years (e.g., mid-1990s). In addition, projected model declines in stock sizes cannot be accounted for solely by the removals attributed to fishing, because the data are absent for the period 1974-1980. Further trends for sandbar and blacktip sharks (the dominant harvest species) are inconsistent with the trends for LCS (see table under Comment 2).

Question 2. *Were the scientific conclusions and scientific management recommendations based on a logical extension of the model's results?*

Response:

If one accepts the model outputs, which I do not, then the scientific recommendations that flow from the model are consistent with the range of model output recommendations suggested by the 1998 SEW Report.

Responses to Directive: *In addition, in reviewing the stock assessment, each reviewer may consider, consistent with his/her expertise, among other relevant considerations:*

Question 1. *how the stock assessment applied the Bayesian modeling approach to the available data and determined the appropriateness of using a non-age specific production model to assess a long-lived species (or species complex)?*

Response:

The Bayesian modelers took the CPUE series from a number of independent vital rate parameters and generated a set of “priors” based on historical data. The historical data used to generate the “priors” was not presented to the reviewer. It is unclear why the modelers opted for a set of intrinsic rates of population increase and K values that led to more pessimistic outcomes than predicted by earlier modeling. There is considerable question as to the quality of the information on age-at-maturity and longevity employed as well as the early CPUE data that is merged and weighted to establish the production model and Bayesian “priors”. The outcomes of the model suggest that aggregate stock recovery will extend over several decades, but the outcomes suggesting that even without fishing the aggregate stocks will not quickly return to unfished levels for an extended period is unclear. This probably reflects the very low intrinsic rates of population increase selected by the modelers. The question is, what “prior” information led to the selection of low “r” values? This is not clearly stated or apparent in the supporting documents provided to the reviewers. Regardless of the modeling approach selected, they all require inputs that must reflect what they are supposed to represent. The overarching assumption in using CPUE data in the Bayesian model is that such data truly represents an index of abundance.

In the discussion of the declines in long-lived, low-fecund animals, the background reports give examples of the rapid decline of several different species. They have however, failed to review the extensive information on the spiny dogfish shark (*Squalus acanthias*). This dogfish species was fished very heavily in the early-1940s and within just over half a decade the population was estimated to have declined to roughly 37 percent of its former abundance. Female dogfish mature at about age 24, while males mature at about age 15. The females give birth to about 7 pups/2 years and the species lives to about 40 years. The life history of the spiny dogfish is, in many respects, similar to the LCS noted in the Atlantic. We should have expected that since the intrinsic rate of population growth was very low, that the rebuilding of the population of Pacific dogfish after the intense fishery in the early-1940s might have taken several decades following the collapse of the fishery in the late-1940s. However, within a decade the governments of both the U.S. and Canada began to receive complaints from the fishing industry about the growing nuisance of dogfish on many of the important commercial and recreational fishing grounds. Within less than 10 years the dogfish shark population had recovered and there were pleas for

government assistance to control the “pest” (Ketchen 1986). How did this slow growing, long-lived, low-fecund species rebuild so rapidly? Ketchen’s (1986) report notes that Wood et. al (1979) developed a model simulating the changing population of the dogfish shark and concluded, “That there is a density-dependent compensatory change in the rate of natural mortality, namely that the natural death rate at all ages decreases as the population increases to its primitive level of equilibrium (r). The density-dependent mechanisms are not completely understood, but reduction in cannibalism may in part explain the reduced natural mortality.” It is not apparent that the LCS modelers made any accommodation for density-dependent factors impacting natural mortality. It appears that this change may have been significant in the spiny dogfish shark stock dynamics and there is no reason to believe that it is not similarly important to the LCS.

Question 2. *how the stock assessment considered the availability and quality (i.e. how the series were estimated, how they were weighted for the analyses, and how they were applied as age specific indices of abundance, particularly for the MRFSS data which accounts for most of the LCS mortality in the early years, other than foreign fishing) of alternative data sets and statistical modeling approaches, including modeling approaches employed in prior shark evaluation workshops)?*

Response:

The various CPUE indexes used in the modeling differ in definition and time/area they represent and the use of weighting techniques are questionable (see Comments Section). The lack of adequate standardization of the data sets further emphasizes the difficulty in equating one set of data to another. It is also unclear why the historical NMFS modeling efforts were abandoned.

Population modeling in the 1998 SEW uses catch per unit effort (CPUE) data as an indicator of shark relative abundance. Since most abundance indices for sharks have been developed through the use of CPUE, the 1998 SEW was forced to assume that the CPUEs across a considerable time period, are proportional to fish abundance and that derived abundance indexes represent relative population size. The manner of CPUE data aggregates, the poor quality of data for the early years, and lack of behavioral information in regard to feeding patterns of sharks, renders the CPUE indices and its linearity questionable.

Many of the shark workshops and shark evaluation annual reports, which support the 1998 SEW, note that the available CPUE series data is extremely variable and are of different quantity and quality (some are nominal, highly aggregated averages from very localized fishing operations while others are based on analyses designed to adjust for area, season, and fishing practices for set-by-set catch and effort fishing operations over a broad area of the ocean, see below). Furthermore, (1) available catch rate information represents a mixture of data time series, (2) some of these data are based on analyses designed to adjust the catch rates for spatio-temporal fishing strategies unrelated to shark abundance, and (3) other time series data sets are highly nominal and might be influenced by factors other the shark relative abundance.

With this in mind, the SEW Committee proceeded to examine the CPUE data, in aggregate, for evidence of trends in catch rates. In order to combine the various catch and effort data into a single series representing an average species or species group catch rate trajectory, a General Linear Model (GLM), controlling for source of data, and testing for a significant tendency between years, was applied to the log-transformed CPUE data. However, The GLM standardization does not generally include operational and gear variables that very definitely could influence catch rates. It is clear that inclusion of these effects in the population estimation models could result in very different patterns of abundance.

The annual CPUE values were weighted in the analysis by the inverse of the precision of the value (i.e., $\text{weight} = 1/\text{coefficient of variation}$). In cases where only nominal information was available, or where no measure of the uncertainty in the annual CPUE series was available, a coefficient of variation of 100 percent was assumed.

As might be expected, the model results have large variability such that it is very difficult to show significant differences in catch rates between any two years. As noted in the 1998 SEW Report (Page 9), "It is believed that more detailed analyses of the more nominal time series would help to reduce the uncertainty about the use of these data sets for indicators of shark abundance patterns." Given the above, it is often difficult to understand exactly what was being analyzed.

Question 3. *how the stock assessment handled and applied information relating to whether the species of LCS under consideration represent open or closed populations in each individual instance?*

Response:

The stock production model and its conversion to the Bayesian modeling assume closed populations (i.e., no net migration rate) from the aggregate LCS species group. I do not believe that the tagging data and other data on shark dispersion support this assumption. Also, based on the information presented in NRC-LCS-50 (Summary of tag and recapture data for 33 species of sharks), it is unlikely that any of the LCS species involve closed populations.

Question 4. *how the stock assessment evaluated the reliability of projections based on the above three considerations?*

Response:

All previous questions respond to this question.

Question 5. *how the stock assessment evaluated the effects of extant regulations on stock trajectories, and weighted the risk of maintaining the status quo until these effects could be evaluated against the costs of an additional immediate reduction in permitted LCS landing levels?*

Response:

I do not believe that there is any way to quantify the risk of evaluating the status quo against an immediate reduction in TAC starting in 1999. The range of CPUE data seem to imply that the aggregate shark stock has stabilized (generally between 1993 and 1997), while the model data suggest at least a few species continue to decline, or that the CPUE data are too few and variable and/or trends are too flat to show statistically significant evidence that the aggregate shark stocks are either increasing or decreasing under the TAC. I suspect that data collected since 1998 may have clarified this issue.

COMMENTS

Comment 1 Industry Report

There are several serious claims incorporated into the Industry Report (NRC-LCS-51), which if true, raise questions about the objectivity of the 1998 SEW Report's findings. First, there is the question concerning the make-up and the manner in which the 1998 SEW Committee conducted its business over the past few years. From a review of the make-up of the participants that comprised the 1994, 1996, and 1998 Workshops, it is evident that the first two Workshops were comprised of individuals from state fisheries agencies, regional councils, science institutions, the fishing industry, and the NMFS. However, in the 1998 Workshop there is a major shift in participants. State and federal council management members, the fishery development foundation and one member of the fishing industry were removed from the forum. These individuals were replaced by three members from the Wildlife Conservation Society (WCS) and a number of NMFS staff. The WCS members submitted the background documents that formed the basis of the shift to the Bayesian modeling approach for the new LCS assessment. A key element of the Bayesian modeling framework, as noted in the report by McAllister and Pikitch (NRC-LCS-27), is to "...specify the indices of policy performance." The authors also note that policy performance is often arrived at by discussions among fishery managers, scientists and industry members. Thus, it seems odd that all of the fishery managers, fishery development foundation staff, and one of the two industry members were left out of the meeting. It is even more surprising that three members from one conservation organization, an organization which supports a no shark fishing policy, were added to the 1998 SEW Committee. Given the change in participants, one must question the objectivity of the 1998 SEW Committee.

Comment 2 Bayesian Model Framework

There are some interesting results from Section 4.1.c Production Modeling in a Bayesian Framework (pages 22-23) in the 1998 SEW Report (NRC-LCS-1). For example, Scenario 1: Large Coastal sharks, baseline, states that the LCS stock had continuously declined from 8,927,100 fish in 1974 to an estimated 1,385,000 fish in 1998 and Scenario 2: Large Coastal sharks, alternative catch, states that the LCS stock size is predicted by the model to have declined from 11,299,000 fish in 1974 to an estimated 2,081,000 fish in 1998. However, neither the 1998 SEW Report nor the supporting papers that describe the Bayesian modeling provide any catch data prior to 1981, and further, the quality and authenticity of the CPUE data is very questionable. The earlier values of stock size are essential for a reasonable estimate of carrying capacity (K), which, along with maximum intrinsic rate of increase are the main parameters in both the production and Bayesian models.

Further, production model fits were done on the LCS group as an aggregate (Scenarios 1 and 2), on the sandbar shark individually (Scenarios 3 and 4), and on the blacktip shark individually (Scenarios 5 and 6). In each case, two scenarios were considered: one based on the baseline catch history (baseline), and one based on the same catch history adjusted for underreporting (alternative catch). Although the NMFS suggested that the analyses for LCS, sandbar sharks, and blacktip sharks should be regarded as separate, it is unclear how the production model

analyses relate to one another. For example, it is unclear why the total baseline and total alternative catch for the sandbar shark and the blacktip shark in 1998 exceed the total estimated catch for the entire LCS group aggregate (see table below). If we add the 1998 sandbar shark estimated catch (Scenario 3; 924,000) to the 1998 blacktip shark estimated catch (Scenario 5; 1,383,000), the total estimated catch for these two species (2,307,000) exceeds the total estimated catch of the entire LCS aggregate (Scenario 1; 1,385,000) by more than 900,000 fish.

| Production Model in a Bayesian Model Detailed results from analyses based on six scenarios From 1998 SEW Report pages 22 -26 Sandbar and Blacktip Shark Comparison with Total LCS | | | | |
|--|----------------------------|-----------------------------|---------------------------------------|-------------------------|
| Baseline Analyses | | | | |
| Year | Sandbar (SB) Scenario 3 | Blacktip (BT) Scenario 5 | Total Baseline SB + BT | Total LCS Scenario 1 |
| 1974 | 3,311,200 | 5,191,700 | 8,502,900 | 8,927,100 |
| 1998 | 924,000 | 1,383,000 | 2,307,000 | 1,385,000 |
| | | | (+922,000) | |
| Alternative Catch | | | | |
| Year | Sandbar (SB) Scenario 4 | Blacktip (BT) Scenario 6 | Total Alternative Catch SB + BT | Total LCS Scenario 2 |
| 1974 | 2,960,000 | 6,103,000 | 9,063,000 | 11,299,000 |
| 1998 | 941,000 | 1,441,000 | 2,382,000 | 2,081,000 |
| | | | (+301,000) | |
| | | | | |

Comment 3 Variations among Catch Per Unit Effort (CPUE) definitions and data series in some of the documents provided by the Court

Below, I note the wide range of definitions for CPUE used by the modelers. It is clearly apparent that the CPUE series are, at a minimum, of different quantity and quality and represent a mixture of time data series or merely aggregate averages of localized fishery operations. As pointed out by the NMFS, all modeling approaches require inputs that should represent what they are supposed to represent. In other words, CPUE should be an unbiased measure of its true quantities. Although it is true that some models are robust to errors in some inputs, the models cannot make up for the lack of accuracy and precision in the basic data.

Since most abundance indices have been developed through the use of CPUE, it must be assumed that the catch rates are proportional to fish abundance and that the derived abundance index represents relative population size. I am not convinced that there is any data to confirm that that CPUE data for any species is necessarily proportional to fish abundance or that the derived abundances accurately reflect stock size.

NRC-LCS-2

Observer program Eastern Gulf of Mexico and South Atlantic

CPUE=sharks caught/10,000 hook-hours fished per set

(monofilament bottom longlines, ranging in length from 6-15 miles, with 500-1200 hooks fished for 10-15 hours)

NRC-LCS-3

North Carolina, Atlantic Florida, and Gulf of Mexico Florida

CPUE=sharks caught/10,000 hook-hours fished per set

NRC-LCS-4

Western Gulf of Mexico

CPUE=sharks caught/10,000 hook-hours fished per set

NRC-LCS-6

Rod and Reel Fishery, Virginia to Massachusetts

CPUE was based on the Lo method for GLM analysis (Lo et al. 1992)

CPUE=logged catch per trip x 100

Note: This method models the proportion of positive (i.e., successful) trips and the catch rate of positive trips separately and then combines the results to yield an index value

Lo, N.C., L.D. Jacobson, and J.L. Squire. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. Can. J. Fish. Aquatic Sci. 49:2515-2526

NRC-LCS-7

NE Gulf of Mexico

CPUE for longlines=number of sharks caught on 10 small hooks fished mid-water per hour

CPUE for gill nets=number of sharks caught per 186m long gill net set per hour

NRC-LCS-9

Artisanal fishery in Gulf of Mexico

CPUE=the number of sharks landed each month/number of trips per month (regardless of fishing gear used, net or longline), for all shark species landed in Tamaulipas, Veracruz, and Tabasco from November 1993 to December 1994

NRC-LCS-14

Chesapeake Bay and adjacent coastal waters

Page 2: CPUE=average sharks collected/100 hooks per hour fished

Page 35: CPUE=100 hook longline covering 1.0 to 1.5 nautical miles, fished for 3-4 hours

NRC-LCS-15

Georgia and East Florida drift gillnet fishery

CPUE=number of sharks caught in 150 to 400m long drift nets allowed to drift for 5 to 30 minutes

NRC-LCS-16

Gill net, St. Andrews Bay, NW Florida

CPUE=a net day= number of sharks caught in one net that fished for 22 to 24 hours

NRC-LCS-17

Shallow, coastal areas of NW Florida

CPUE=number of sharks caught on 10 hooks/hour

NRC-LCS-19

Gulf of Mexico Reefish Logbooks

CPUE (for bottom longlines)=pounds/(n lines x (hooks/line))

Where: n lines=number of reported lines used

Hooks/line=average number of hooks used per longline

CPUE (for handlines)=pounds/(hours x n lines x (hooks/line))

Where: hours is the total number of hours the gear was fished for a reported trip

NRC-LCS-23

Tuna fishery bycatch – U.S Atlantic Fleet

CPUE=catch rate=dead discards/hooks x 1,000

NRC-LCS-24

Western North Atlantic

CPUE=catch/1,000 hooks

NRC-LCS-25

Delaware Bay

Gill nets (monofilament set for 1.5 to 6.5 hours)

CPUE=number of sharks divided by the number of set hours (sharks per hour)

Bottom-set longline (one hour set)

CPUE=number of sharks captured divided by the number of hooks set, then multiplied by 100 (sharks per 100 hooks)

NRC-LCS-30

Gulf of Mexico and Eastern Seaboard

CPUE=sharks captured/100 hook hours

(randomly selected 1-mile, 100-hook bottom longline fished for 1-hour)

NRC-LCS-34

U.S. Atlantic, Gulf of Mexico, and Caribbean

CPUE=dead discards/hooks x 1,000

NRC-LCS-35

Northern Gulf of Mexico, Campeche Banks, Caribbean, Atlantic

CPUE=number sharks caught/100 hook hours

NRC-LCS-40

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Appendix – Catch Rate Indices (page 19)

Reef Fish Logbooks

CPUE=pounds/hook hour

(catch as reported is the condition in which the sharks were landed, there was no conversion to gutted or cored weight or any other weight)

North Carolina Division of Marine Fisheries Data

A general linear model procedure was performed on the data set testing for year, wave (2 month period), miles per set, and hooks per mile of longline set, and

CPUE=either kg or number of fish per 10,000 hook hours

VIMS Fishery Independent Data

CPUE=the total number of sharks caught for the total number of hooks fished, multiplied by 100 within each sampling category, although the number of hooks per set increased over time

NRC-LCS-46

South Carolina

CPUE=number of sharks/100 hook set (soak time 4 or 12 hours)

Comment 4 CPUE Data Factors of Concern

Trent and Carlson (NRC-LCS-17) provide evidence of factors that can affect CPUE data. The authors found that differences in CPUE were significant in areas sampled, and when species were compared, circle hooks outfished “J” hooks except for sandbar and bonnethead sharks, and for blacktip sharks with baits on the bottom. Off-bottom baits outfished bottom baits for each species except bonnethead sharks. Several factors are of concern regarding affect on CPUE were noted for longlines, gill nets, or both.

Trent and Carlson also note that CPUE of sharks was significantly greater for the 45 min vs the 90 min soak time in each area sampled, and concluded that it is very important to keep soak time constant in estimating CPUE.

Other factors of importance in estimating shark abundance are:

- Catchability cycles throughout the 24 hr period
- Station locations and sampling frequency
- Hook and bait types environmental factors including red tide, turbidity, direction of current, amount of vegetation and debris in the water
- Susceptibility of each species to being caught on longline or in gill nets
- Fishing power differences between gill nets and longlines due to “saturation” effect (longlines quickly lose their fishing power as the hooks become occupied or if the bait is lost)
- Attraction of each species to lines already containing caught fish.
- Differences in shark feeding habitats among species and among year classes
- Species mix of sharks
- Species (age- and/or size-class) aversions
- Gill nets can be more efficient at catching particular sizes of shark than longlines (highly selective depending upon mesh size used)

Comment 5 Standardization of Age-Class Designations

In addition to differences in CPUE definitions, gear types and sampling methodologies, there appears to be no standardized category designations for identifying various age classes (or sizes) of the sharks. This lack of a standardized designation of age classes makes it very difficult to compare findings among the various studies and study regions. In some of the supporting documents, sandbar sharks (and other sharks) are designated as juvenile, or adolescent or subadult, in others, they are classified as small or large juvenile or young or large adult. In still other studies, sandbar sharks are separated by male and female, with no attempt at consistency among corresponding subcategories. For example, in NRC-LCS-3 males are designated as juveniles, sub-adults, and adults, whereas females are designated as immature, maturing, maturing, non-pregnant, but carried young before, post-partum, or pregnant.

RECOMMENDATIONS

1. The NMFS should attempt to standardize the abundance indices data sets and incorporate them into a single model accepted by all interest and user groups.
2. The SEW should be open to a appropriate balance of individuals including the state agencies, Council planning staff, and an equal number of industry and conservation members.
3. NMFS and other SEW scientists should explore the possibility that K and r rates may be higher than currently assumed.
4. NMFS and SEW scientists should explore the possibility that many, if not all, sharks exist in open populations, that population parameters are not stationary, and that the populations may not respond instantaneously to changes in the magnitude of fishing.
5. The aggregation of the LCS into a single model should be reviewed and the possibility of a dominant species quota and bycatch limits considered.
6. I am in agreement with those concerned that long-lived, low fecund species and late-maturing species can be quickly over-fished. However, the CPUE data sets from the mid-1990s do not support the contention of a continued decline in the aggregate LCS population. It is my suggestion that all CPUE data from 1998 and later years be evaluated along with further modeling work to establish a TAC for future shark fishing regions. If the CPUE data points remain high then the 1998 Bayesian model is likely incorrect, but if the points decline, the model may indeed be correct.
7. NMFS and other management entities should make every effort to collect information and manage species separately. Based on the supporting information provided by the Court, it appears that individual species may be responding differently to exploitation. A risk neutral strategy for LCS aggregates probably result in excessive regulation for some species and perhaps, excessive risk of overfishing for other species.
8. I agree that management options should consider restrictions on effort, size limits, quotas, and area closures (especially nursery grounds), however, until reliable data, required by most stock assessment techniques (especially catch and landing data) are available, our ability to compare management options, let alone the need for them, will be limited.
9. A practical technical requirement with any management plan is to “bound” the system of concern. The actual boundary of the LCS FMP is unclear. Historically, it appears that this was accomplished by focusing on one or more species of concern (e.g., sandbar or blacktip shark) over a defined area. However, the FMP has authority over 39 species, occurring within a wide geographical area, including international waters, with widely varying fisheries management regulations and data reporting requirements. The FMP needs to identify fishing (i.e., reporting) areas, which should correspond to regulatory areas within Fishery Management Units defined under the FMP. Because of the wide ranging nature of many of the shark species managed under the FMP and because management options vary by the scale of consideration, it is essential to define clearly the boundary of concern. For example, a set of decisions to protect LCS along the entire Atlantic coast of the U.S. may be very different than the decision set for smaller areas (e.g., Florida Atlantic coast). The definition of the management problem should define the scale to be used in each analysis. The same

problem analyzed at different scales will likely lead to very different management strategies.

REFERENCES

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Wood, C.C., K.S. Ketchen, and R.J. Beamish. 1979. Population dynamics of spiny dogfish (*Squalus acanthias*) in British Columbia waters. J. Fish. Res. Bd. Can 36:647-656.